VOL. XLIII, NUMBER 6 WHOLE NUMBER 381

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, F. S. HOGG

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

J. A. PEARCE
Dominion Astrophysicist
Victoria, B.C.

A. THOMSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED BI-MONTHLY
(*Six numbers per year*)

November-December, 1949

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLIII, No. 6 NOVEMBER-DECEMBER, 1949 WHOLE No. 381

Articles PAGE

The Extent of the Chromosphere of the K-type Component of Zeta Aurigae ..... *H. L. Welsh* 217

Observations of the Total Solar Eclipse at Araxa, Brazil, 1947 May 20 ..... *James Hargreaves* 229

Out of Old Books

Jean Sylvain Bailly, The Guillotined Astronomer (concluded) *Helen Sawyer Hogg* 237

Review of Publications

The Conquest of Space by Chesley Bonestell and Willy Ley (*J.F.H.*); Scientific Autobiography and other papers by Max Planck; Tycho Brahe's Description of his Instruments and Scientific Work translated and edited by Hans Raeder, Elis Strömgren and Bengt Strömgren (*C.A.C.*) 241

Notes and Queries

Bright October Meteors over Ontario (*J.F.H.*); Victoria Centre's "Brydon" Telescope; Four Eclipses in one Evening (*F. K. Dalton*) 247

Meetings of the Society

At Toronto—At Quebec 251

Index to Volume XLIII 254

Table of Contents of Volume XLIII ..... i-iv

Upon request, made previous to publication of article, contributors will be supplied free with twenty-five copies of the sheets containing the article.

Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence and remittances should be addressed to J. H. Horning, Treasurer of the Society, 3 Willcocks St. Toronto.

$3.00 per annum, Single number, 50 cents.

Subscription to the JOURNAL is included in membership fee.

ANNOUNCING A NEW SERVICE

24 35 mm slides – 11 charts – 13 Mt. Wilson Sky Pictures – in sturdy glass mountings – $8.50.

ASTRONOMY CHARTS

The set of 25 charts, 8½ × 11 – punched for loose-leaf folders – $3.00.

Single Wall Charts – 27 × 35 (duplicates of small charts) – $3.00 each.

We are sorry that increased costs make this price advance necessary.

Circular? – Drop us a card.

ASTRONOMY CHARTED

4 MASON ST., WORCESTER, MASS., U.S.A.

PRINTED IN CANADA

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XLIII, No. 6 NOVEMBER-DECEMBER 1949 WHOLE No. 381

THE EXTENT OF THE CHROMOSPHERE OF THE K-TYPE COMPONENT OF ZETA AURIGAE*

By H. L. WELSH†

ABSTRACT

The chromospheric absorptions of the calcium *K*- and *H*-lines were measured on sixteen spectrograms obtained at Victoria before and after the most recent eclipse of Zeta Aurigae, December 1947 - January 1948. These measurements were supplemented by nine plates loaned by the University of Michigan and three plates loaned by the Mount Wilson Observatory. During egress the *K*-absorption was observed up to 10 days after last contact. A similar extent of the calcium atmosphere of the K-star has been observed for one ingress and two egresses in earlier eclipses. This extent may probably be considered "normal". During ingress in the 1947-48 eclipse the atmosphere was abnormally extensive, a faint *K*-line being observed 47 days before first contact. An abnormal atmosphere, of approximately the same extent, has been observed on two previous occasions, once during ingress and once during egress. The occurrences of the abnormally extensive atmosphere are compatible with the assumption that the atmosphere, rotating with the K-star, has a permanent asymmetry.

INTRODUCTION

THE composite spectrum of Zeta Aurigae was first noted by Miss Maury,[1] and the binary character of the star definitely established by Campbell[2] from radial-velocity measurements. The ele-

*Contributions from the Dominion Astrophysical Observatory, No. 21.

†Department of Physics, University of Toronto.

[1]*Harv. Ann.*, vol. 28, p. 99, 1897.

[2]*Lick Obs. Bull.*, vol. 5, p. 62, 1908.

ments of the spectroscopic orbit of the system were found by Harper[3] from a long series of observations extending over the years 1917-1924. The composite spectrum shows that one of the components is a late K-type star, the other probably a B-type star. On one of Harper's spectrograms, obtained on January 18, 1924, the K-type spectrum was alone apparent, indicating that the B-star was in total eclipse. On the basis of Harper's observations Bottlinger[4] predicted the times of future eclipses, and the first extensive studies of an eclipse were made in 1932 by Guthnick and Schneller,[5] and by Hopmann.[6] The following eclipses, occurring at intervals of approximately two and two-thirds years, were studied by many observers, the eclipses of 1934, 1937, 1939-40 and 1947-48 being generally the most favourable for observation.

From the wealth of spectroscopic and photometric data obtained much is known about this interesting eclipsing system, but uncertainties, especially in interpretation, still remain. The period of the binary is 972 days and the duration of the total phase of the eclipse about 37 days. The partial phases last about 1.25 days, and are not sharply defined, probably because of scattering of the B-star's light in the atmosphere of the K-star. The durations of the partial and total phases indicate an enormous disparity in the sizes of the two components. A review of those constants of the system which are of interest in this investigation has been given by Wilson.[7] The diameter of the K-type supergiant is probably of the order of 200 times the diameter of the sun, while the diameter of the B-star is only about one-seventieth as great as that of the K-type component. The inclination of the orbital plane of the binary is approximately 90°, so that the eclipse is not far from central.

It was observed by Guthnick and Schneller in 1932 that the short wave-length region of the composite spectrum, dominated by the continuous spectrum of the B-star, is marked by sharp absorption lines for a period of some days before and after the eclipse. The lines are due to absorption of the light of the B-star in the extended

---

[3] *P. Dom. Ap. O.*, vol. 3, p. 151, 1924.
[4] *A. N.*, vol. 226, p. 239, 1926.
[5] *Sitz. Ber. d. Preuss. Akad. d. wiss.*, Phys.-Math., p. 57, 1932.
[6] *Ber., Akad. d. wiss. Leipzig*, vol. 85, p. 117, 1933.
[7] *Ap.J.*, vol. 107, p. 126, 1948.

atmosphere of the K-star. Because of the smallness of the disc of the B-star relative to the extent of the atmosphere of the K-star, the light of the B-star constitutes a fine probe moving through the atmosphere of the K-star before and after the eclipse. The system thus offers an unparalleled opportunity for studying the composition and extent of the chromosphere of a supergiant K-star. Observations of the chromospheric absorption have shown a distribution of elements in the atmosphere of the K-star similar to that in the atmosphere of the sun, but on a greatly expanded scale. Neutral and ionized metals are present in the lower layers, and ionized metals predominate in the higher layers. In the highest layers, at enormous distances from the surface of the star, only hydrogen and ionized calcium are detectable.

One of the most interesting features of the chromosphere is its varying extent. This was first pointed out by Guthnick, Hachenberg and Schneller,[8] who observed that during egress in 1934 the calcium *K*-line persisted only about 10 days, whereas it was observable at least 30 days after the last contact in 1932. A calcium atmosphere of great extent was also present during ingress in 1937 according to Beer.[9] The measurements of Christie and Wilson[10] and of Beer[11] for the 1934 eclipse, and of Wilson[7] for the 1939-40 eclipse do not indicate that the chromosphere was abnormally extensive on these occasions. The variation in the extent of the atmosphere thus does not seem to bear any simple relationship to the orbital motion of the system. The observations indicate either (a) a permanent asymmetry in the atmosphere of the K-star, rotating with the star with a period different from the orbital period, or (b) a sporadic effect similar to the appearance of solar prominences but of vastly greater proportions. Another possibility is that the extensive atmosphere of the giant K-star is set into some kind of periodic oscillation or pulsation by the varying tidal force produced by the B-star. This explanation is not considered likely to explain the times of abnormal atmospheric extent nor its amount but it should not be ruled out entirely.

For the most recent eclipse of Zeta Aurigae, December 1947-

[8] *Abh. d. Preuss. Akad. d. wiss.*, Phys.-Math., No. 1, 1935.
[9] *M.N.*, vol 100, p. 693, 1939-40.
[10] *Ap.J.*, vol. 81, p. 426, 1935.
[11] *M.N.*, vol. 95, p. 24, 1934.

January 1948, a number of spectrograms were obtained at Victoria, which permitted a new study of the chromospheric absorption especially during egress. The Victoria observations were supplemented by plates loaned by the University of Michigan. The few plates available for the period of ingress showed that the chromospheric absorption was very strong on the days immediately preceding first contact. It thus appeared probable that the atmosphere was abnormally extensive during ingress. This was confirmed by three plates loaned by the Mount Wilson Observatory, covering a period of seven weeks before the eclipse.

Since the main interest in the present investigation was the extent of the atmosphere of the K-star, measurements were made only on the *K*-line of Ca II, and, to a lesser extent, on the *H*-line. It was also considered unnecessary for the object in view to study the chromospheric absorption during the partial phases, since the measurements are complicated by the partial obscuration of the disc of the B-star. Finally, a survey of the available data on the *K*-line absorption for all eclipses of Zeta Aurigae was made in an attempt to discover any regularity which might exist in the varying extent of the chromosphere.

The 1947-48 Eclipse

The Victoria plates were obtained with the IM spectrograph which gives a linear dispersion of 19.9 A./mm. at the *K*-line. The Michigan spectrograms had a slightly smaller dispersion, 26.4 A./mm. The three Mount Wilson spectrograms had dispersions of 2.9, 10.3 and 23.2 A./mm. Microphotometer tracings of the *K*- and *H*-lines were converted to intensity contours with the intensitometer[12] using intensity calibrations which had been recorded on each plate. The integrated intensity of absorption for each line was then converted to an equivalent width in Angstroms. No difficulty was experienced in obtaining the background for the chromospheric *K*-line, since the *K*-line of the K-type star is very broad and, outside of the partial phase, is almost completely filled in by the continuum of the B-star. The chromospheric *H*-line was more difficult to measure accurately since it lies inside the deep absorption, H_ϵ of the B-star, and is blended to some extent with the chromospheric H_ϵ-line.

[12] *J.R.A.S.C.*, vol. 38, p. 65, 1944.

TABLE I

K- AND *H*-LINES FOR THE 1947-48 ECLIPSE OF ZETA AURIGAE
EQUIVALENT WIDTHS OF THE CHROMOSPHERIC

Plates	J.D. 2432000 +	Time from mid-eclipse Δt (days)	Equivalent widths in Angstroms	
			K - Line	*H* - Line
Victoria				
Plates				
37998	530.95	−22.6	1.22	
38114	574.83	+21.3	0.97	
38115	574.88	+21.4	1.02	0.91
38120	575.78	+22.3	0.91	
38122	576.59	+23.1	0.88	0.61
38123	576.61	+23.1	0.81	0.71
38143	578.59	+25.1	0.53	0.37
38144	578.61	+25.1	0.48	0.30
38161	580.65	+27.2	0.22	
38175	580.87	+27.4	0.16	
38184	581.59	+28.1	0.13	
38190	581.71	+28.2	0.14	
38194	581.86	+28.4	0.11	
38195	583.60	+30.1	0.05	
38197	583.73	+30.2	0.04	
38219	586.66	+33.2	0.00	
Michigan				
Plates				
17217-3	529.70	−23.8	1.36	1.07
17220-D	531.72	−21.8	1.58	1.37
17249-D	573.79	+20.3	1.28	0.86
17253-D	574.71	+21.2	1.02	1.09
17257-A	576.70	+23.2	0.90	0.90
17259-D	578.62	+25.1	0.54	0.36
17260-B	579.63	+26.1	0.34	
17263-B	581.61	+28.1	0.25	
17265-A	582.60	+29.1	0.00	
Mount Wilson				
Plates				
Ce 4944	486.90	−66.6	0.05 (0.07)*	
29148	514.99	−38.5	0.18 (0.26)*	
Ce 4991	529.71	−23.8	0.96 (1.38)*	0.70 (1.00)*

*The bracketed values are the measured values raised by 44%.

Hence measurements of the H-line could not be obtained from all the plates. The measured equivalent widths are given in Table I.

It is convenient to relate the equivalent widths to Δt, the time in days from mid-eclipse. Unpublished photometric data by Kron for the 1947-48 eclipse give the epoch of mid-eclipse as J.D. 2432553.5, and this is confirmed by the measurements of Pettit.[13] If the dura-

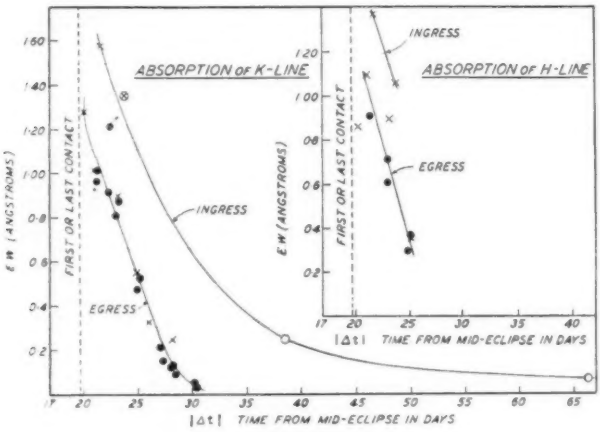

FIGURE 1

Variation of the chromospheric K- and H-line absorptions during ingress and egress in the 1947-48 eclipse of Zeta Aurigae.

●—Victoria Plates
×—Michigan Plates
○—Mount Wilson Plates

tion of the eclipse is taken as 39.50 days, the first or last contact is given by $\Delta t = 19.75$ days.

The variation of the intensities of the K- and H-lines with Δt is shown in figure 1. Good agreement was found between the measurements from the Victoria plates and those from the Michigan plates. During egress the chromospheric K-line could be followed for about ten days after last contact. The change in the absorption proceeds smoothly, and over a large portion of the curve the equivalent width

[13] *P.A.S.P.*, vol. 60, p. 102, 1948.

varies linearly with Δt. The measurements for the H-line are more scattered, but show a variation of the absorption similar to that of the K-line.

During ingress both the density and the extent of the chromosphere were much greater than during egress. The density of the chromosphere is taken to be indicated by the strength of the absorption whereas the extent of the chromosphere is given by the duration of appearance of the chromospheric lines. If we are observing localized phenomena the density and extent are distinguishable, but if a state of spherical symmetry always exists in the atmosphere this is not so. The few measurements obtainable from the Victoria and Michigan plates showed that the K- and H-absorptions were considerably greater just before first contact than at the corresponding times during egress. The Mount Wilson plate taken on J.D. 529.71 gave an equivalent width of 0.96 A., while the Michigan plate taken at almost exactly the same time gave the value 1.38 A. Lower values for the equivalent widths of spectral lines from grating plates obtained at Mount Wilson compared with intensities from prism spectrograms secured at the Dominion Astrophysical and the McDonald Observatories have been noted and remarked upon by Merrill, Sanford, Wilson and Burwell[14] and by Aller.[15] The former found a difference of 30 per cent and Aller, who suggested the difference arose from scattered light, 20 per cent. The equivalent widths from the Mount Wilson plates were therefore raised by 44% to obtain agreement with the Michigan value on J.D. 529.70 and, presumably, with the scale of the values from the Victoria plates. These modified values, bracketed in Table I, were used in plotting the curve of figure 1. This arbitrary adjustment of the intensities from the Mount Wilson plates does not matter greatly, since sufficient observations were not available to obtain the trend of the absorption with exactitude. The essential point is that an abnormal extent of the atmosphere during ingress is clearly established.

The absorption observed for J.D. 486.90, almost seven weeks before first contact, corresponds to a traversal of the chromosphere by the light of the B-star at a distance from the photosphere of the K-star of roughly 1.25 diameters of the supergiant K-star. At these

[14] *Ap. J.*, vol. 86, p. 205, 1937.
[15] *Ap. J.*, vol. 109, p. 244, 1949.

great heights in the chromosphere the weak absorption, varying slowly with height, suggests a tenuous prominence extending to enormous distances from the surface of the K-star. However, the density of ionized calcium even in the lower strata of the chromosphere is much greater during ingress than during egress, indicating a general asymmetry in the atmosphere.

Comparison With Earlier Eclipses

Since data relating to the chromospheric K-line absorption for some earlier eclipses are available in the literature, it seemed worthwhile to make a comparison of the extents of the chromosphere on various occasions. The results of this survey are given in figure 2.

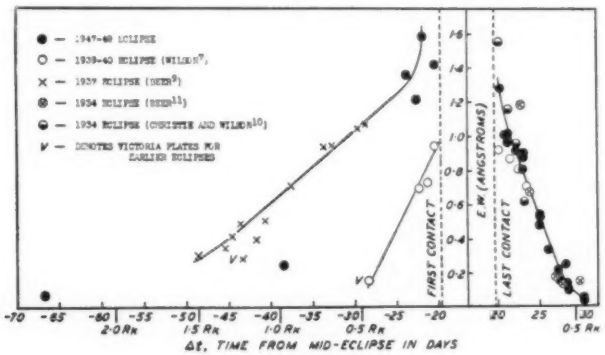
● — 1947-48 ECLIPSE
○ — 1939-40 ECLIPSE (WILSON[9])
× — 1937 ECLIPSE (SEEB[9])
⊗ — 1934 ECLIPSE (SEEB[11])
⊖ — 1934 ECLIPSE (CHRISTIE AND WILSON[10])
V — DENOTES VICTORIA PLATES FOR EARLIER ECLIPSES
E.W. (ANGSTROMS)
FIRST CONTACT
LAST CONTACT
-70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 20 25 30
2·0 R_K
1·5 R_K
1·0 R_K
0·5 R_K
0·5 R_K
Δt, TIME FROM MID-ECLIPSE IN DAYS

Figure 2

Comparison of the variation of the chromospheric K-line absorption during ingress and egress in different eclipses of Zeta Aurigae.

The second scale added to the Δt-axis gives the height in the chromosphere in terms of R_K, the radius of the K-star. The heights were calculated from the approximate formula

$$h = (0.0514\ \Delta t - 1)\ R_K$$

in which a constant relative velocity of the two components is assumed.

The curve for egress drawn in figure 2 is the best representation of the points obtained in this investigation for the 1947-48 eclipse.

It is seen that this curve also represents in a satisfactory manner the trend of the absorption during egress in the 1934[10, 11], 1937[9] and the 1939-40[7] eclipses. It is therefore concluded that the atmosphere of the K-star had essentially the same extent on these occasions, and that this extent might be considered as "normal".

During ingress in the 1939-40 eclipse three measurements obtained by Wilson[7] shortly before first contact give points somewhat lower than the "normal" curve. Fortunately, a Victoria plate taken nine days before the first contact was available and was measured. The point thus obtained makes it fairly certain that the trend of the absorption is the same as that for the four egresses discussed above, and that the extent of the chromosphere was normal during this ingress.

TABLE II

Eclipse	Extent of the Chromosphere of the K-star	
	During Ingress	During Egress
1932		abnormal
1934		normal
1937	abnormal	
1939-40	normal	normal
1947-48	abnormal	normal

The long series of measurements by Beer[9] during ingress in 1937 shows in a striking manner the "abnormal" extent of the chromosphere on this occasion. The curve drawn to represent Beer's measurements lies somewhat higher than the points for the 1947-48 eclipse. However, there is a marked resemblance in the abnormal extents of the atmosphere for these two ingresses. The one measurement by Christie and Wilson[10] for ingress in 1934 lies rather closer to the normal trend than the abnormal, but not much weight can be attached to a single measurement.

If only the measurements presented in figure 2 were taken into account one would be inclined to conclude that during egress the chromosphere of the K-star is always normal and during ingress is sometimes abnormal. That this is not the case is shown by the description by Guthnick and Schneller[5] of the variation of the *K*-absorption on spectrograms taken during egress in 1932. The chromo-

spheric K-line was observed as late as thirty-three days after last contact, and during this interval there was a more or less gradual diminution in its intensity. It is therefore clear that in this eclipse the chromosphere was abnormally extensive during egress, and that the extent was probably of the same order as for the other two known abnormal cases.

A summary of this comparison of the various eclipses is given in Table II.

Discussion

In view of the rather small number of observations it would be unwise to attempt to draw any firm conclusions regarding a possible periodicity in the occurrence of the abnormal atmosphere of the K-star. However, since an abnormal atmosphere has been observed on the receding side of the star during eclipse as well as on the advancing side, one possible explanation is to ascribe it to a permanent asymmetry in the atmosphere of the star. In this case one should be able to relate the occurrences of the abnormal atmosphere to the period of rotation of the star. The entries in Table II can easily be shown to be compatible with a rotational periodicity with any one of the periods $4T$, $(4/3)T$, $(4/5)T$, $(4/7)T$ ..... where $T = 972$ days is the orbital period of the binary. One of these periods, $(4/5)T = 778$ days, is very close to the value of 785 days found by Christie and Wilson[10] for the period of rotation of the K-star from radial-velocity measurements on the chromospheric K-line near the partial phase. Although the good agreement is probably accidental, it gives some indication that the abnormally extensive chromosphere may be a permanent asymmetry in the atmosphere of the K-star rather than a prominence occurring sporadically. It does not follow of course that the whole extended prominence rotates with the K-star. Indeed, the measurements of Guthnick, Hachenberg and Schneller[8] show that the rotational effect in the chromospheric absorption decreases rapidly with height above the photosphere, even for the normal atmosphere. A correct picture would be that the condition in the photosphere which produces the prominence, rotates with the K-star. It is difficult, however, to visualize what this condition must be.

It should be noted that if a periodicity exists, as postulated above,

an abnormal atmosphere should have been present during egress in the 1942 eclipse. There seem to be no *K*-line absorption measurements available to verify this. Also, one can predict that for the eclipse occurring early in 1956, the next which can be easily observed, the atmosphere should be normal both before and after the eclipse as in 1939-40.

McLaughlin[16] has recently published a description of the Michigan plates for the 1947-48 eclipse, and has compared the extents of the atmosphere for various eclipses. The comparison was made by examining the chromospheric absorption lines with a spectrocomparator and setting up a scale of "Atmospheric Eclipse Intensities". Since the conclusions reached by McLaughlin are significantly different from those reached here, some comment is necessary.

McLaughlin's main conclusions are that the absorption on the advancing side of the K-star during eclipse is always more extensive than on the receding side, and that the only abnormally extensive atmosphere was that observed during ingress in 1937. The Mount Wilson plates used in the present investigation show, however, that in 1947-48 the atmosphere during ingress was in fact very extended; the series of Michigan plates, beginning at $\Delta t = -23.8$ days, showed a higher than normal chromospheric absorption but could not give a proper conception of the extent of the atmosphere. The measurements plotted in figure 2 for 1939-40 show a normal trend for ingress; the three measurements presented by McLaughlin for this case also do not depart far from the normal. Finally, for the 1934 eclipse the equivalent widths for the *K*-line at $\Delta t = -20.7$ and $\Delta t = +20.2$ days, given by Christie and Wilson, and plotted in figure 2, do not indicate an asymmetry in the atmosphere on this occasion. However, the measurements given by these authors for other chromospheric lines indicate that approximately half of the lines were more intense on the advancing side of the star. The evidence for this eclipse is therefore somewhat inconclusive.

It would be highly desirable to have future eclipses of this interesting star observed under as uniform conditions as possible so that successive observations are strictly comparable. For this reason, it is to be hoped that those who have observed the eclipses of Zeta

[16] *Ap. J.*, vol. 108, p. 237, 1948.

Aurigae in the past will observe future eclipses with identical equipment wherever possible.

The author gratefully acknowledges his indebtedness to Dr. J. A. Pearce, Director of the Dominion Astrophysical Observatory, who enabled him to spend the summer of 1948 at Victoria, to Dr. R. M. Petrie and Dr. A. McKellar who suggested the investigation reported here and who gave assistance in many ways, to Dr. D. B. McLaughlin of the University of Michigan and Dr. O. C. Wilson of Mount Wilson Observatory for the loan of spectrograms, and to Dr. G. E. Kron of Lick Observatory for photometric data on the 1947-48 eclipse of Zeta Aurigae.

Department of Physics
University of Toronto
July 1949

OBSERVATIONS OF THE TOTAL SOLAR ECLIPSE AT ARAXA, BRAZIL, 1947 MAY 20

By James Hargreaves

At Araxa, the weather was unfavourable on the day of the eclipse and our main programme was a failure. However a record of the brightness of the sky was kept. The observations, which give an indication of the manner in which light is scattered in the earth's atmosphere, are now presented and discussed. It appears that there is an important amount of scattered light coming in from quite long distances and this circumstance suggests a line of investigation which might be profitably followed on a future occasion.

Observations. The object of our visit to Brazil had been to make photometric studies of the solar corona and equipment had been planned which could be handled by two persons. When Mr. and Mrs. C. C. Batchelder joined us and offered their services we were very glad of the opportunity to suggest a programme for their light-meter. Measurement of the light scattered by the sky was aimed at, hoping for some sort of answer to the question, How dark was the eclipse? It seemed also that such measurements might furnish information about the background illumination, if the sky were clear. The observations secured are given in the table below.

The instrument used was a General Electric Light Meter, Model 8 DW4042. Essentially this is a selenium cell permanently coupled to a micro-ammeter. The sensitive element has a glass cover with a clear opening $1\frac{1}{2} \times \frac{3}{4}$ inches. Two detachable metal screens are provided. In use these screens lie close to the cover glass and reduce the total amount of light entering without making any great change in the angular opening, which is a hemisphere. One screen has a rectangular hole $\frac{1}{2} \times \frac{3}{16}$ inch, the other a round hole about $\frac{1}{8}$ inch in diameter; both holes are centrally located.

A calibration was made at Ottawa, by the Optics Section of the National Research Council, with an "artificial sky" consisting of a larger plate of flashed opal glass, flashed side towards the meter. Artificial light of colour temperature 6500° K. was used, except for the higher values of luminance when the plate was illuminated by natural daylight. The spectral sensitivity of meters of the type used is exhibited by figure 1, based on data supplied by the manufacturer. During the eclipse the meter was fixed with the sensitive

surface horizontal, facing the zenith. The readings were timed with a watch with a sweep seconds hand.

The position of the camp was determined from maps supplied by the Minas Gerais State Survey Department and checked back from the position of the Swedish Camp, where an accurate geodetic determination was made. The height above sea level is known only approximately.

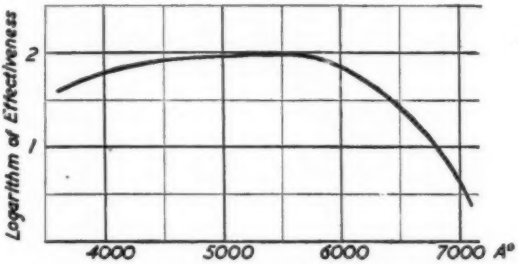

FIG. 1—Spectral sensitivity of typical light meter.

The circumstances of the eclipse had been calculated from an ephemeris prepared by Alfredo Volsch and published at Cordoba in 1945. This publication was used as source of the Bessel Elements throughout the discussion which follows.

At Araxa, the eclipse took place in the morning between eight and twelve o'clock. About the time of first contact we saw a patch of sky bright enough to encourage some hopes of a break: we pointed our instruments roughly towards it and started the motor but we never caught the sun in the field of the guiding telescope. Towards fourth contact the clouds again seemed to be thinner but the sky did not clear till after noon.

During the morning there was very little surface wind and the lower clouds appeared to make a fairly uniform canopy. The short term changes, which were appreciable and shown by the meter readings, seemed to be due to clouds passing at a higher level. The surface wind, when there was any, came from the west; opposite to the prevailing direction. We made particular note of this because when preparing our camp we had taken elaborate precautions to guard against dust, laying floor boards and cement around the instruments and keeping off the bare ground on the east side.

Time	Meter reading	Brightness (ft. lamberts)	ζ'
11h 00m	10 *aa*	1680	.31701
15	10 *aa*	1680	.36672
20	8 *aa*	1350	.38285
30	5.5 *aa*	925	.41439
40	4.5 *aa*	755	.44491
50	5 *aa*	840	.47437
12 00	3 *aa*	505	.50271
24	70	74.25	.56585
25	55	58.5	.56833
26	24	25.5	.57079
27	11	11.6	.57324
32	10	10.5	.58528
33	14	14.8	.58764
34	30	32	.59000
35	55	58.5	.59234
36	70	74.25	.59467
42	28 *a*	330	.60836
45	30 *a*	355	.61501
50	53 *a*	670	.62583
13 00	11 *aa*	1845	.64640
10	16 *aa*	2660	.66553
20	16 *aa*	2660	.68317
30	19 *aa*	3155	.69929
45	30 *aa*	(4960)	.72057

The first two columns give the observer's time and meter readings, *a* indicating that the screen with the rectangular hole was in place and *aa* that the screen with the small hole was on the instrument. The third column gives the brightness of the sky, as deduced from the calibration of the meter, the last entry, 4960, indicating an extrapolation. The fourth column gives the cosine of the zenith distance of the axis of the shadow ζ', at observer's time + .456 min.

Assumed position of the camp: $\lambda = 46° 56.5'$ West, $\phi = 19° 40.2'$ South, $h = 1000$ metres above sea level.

Circumstances of the eclipse, 1947 May 20,

First Contact	11h	18m	56.4s	U.T.
Second "	12	28	40.6	
Third "	12	32	17.3	
Fourth "	13	51	26.4	

MRS. C. C. BATCHELDER,
Observer.

Discussion. The results of the measures of sky brightness are illustrated in figure 2. There are two features of these observations which call for study, (1) the possibility of determining the times of contacts, and (2) the explanation of the shape of the light curve, at middle times, and of the residual light at beginning and ending of totality.

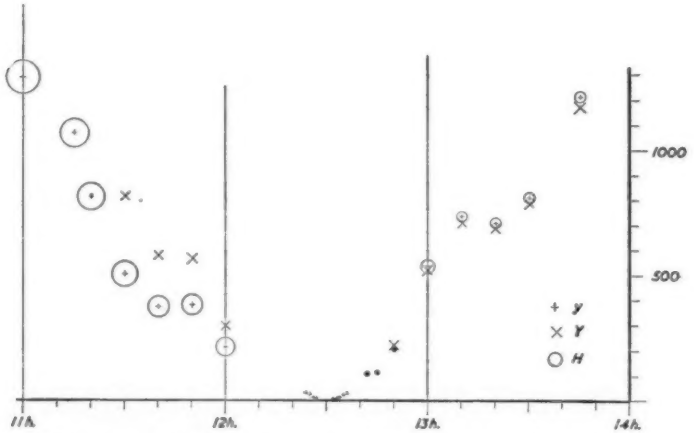

FIG. 2—Sky brightness measures during solar eclipse at Araxa, Brazil.

Times of Contact. Since the light curve slopes steeply a few minutes before and after totality, it is possible to calculate the times of contact. But allowance must be made for the changing zenith distance of the sun and for the altitude and erratic absorption of the clouds.

A least-squares solution, for the fit of a curve of type

$$a_0 + a_1x + a_2x^2 = 0^1$$

to the nine central observations, leads to a clock correction of + 0.475 minutes (to be added to the observer's times) when the change of zenith distance is allowed for and of + 0.400 minutes

[1]In the symbolism of Chauvenet, Ch. X.

$$x = 1000\ (1 - D) = 1000\ (m + L_2)/(L + L_2)$$

a solution in terms of x, rather than time, eliminates some of the causes of assymmetry.

when a further allowance is made to smooth out the irregular cloud effect in the first half of the eclipse.[2] These results are of no value for positional work because the observations were not accurately timed, but the difference, 0.075 minutes, or say 4.2 seconds, shows that even if accurate timing had been possible an error of this order might be expected under similar cloud conditions.

Calculations for this eclipse show that for each 1000 metres height of the cloud layer above the observer, up to 4000 metres, the corrections to times of second and third contact are -1.09 and -1.05 seconds, respectively. Thus, if it should be possible to overcome the error due to drifting clouds, the mean height of the scattering layer could then be estimated. At an eclipse observed in a clear sky, and with the zenith distance sufficient to make this differential measurable, comparison of the light curves for scattered and direct radiation should lead to quite accurate results, if any meaning can be given to the expression "mean height of the scattering layer."

Light Curve. The most interesting feature of these observations is the amount of residual light at second and third contacts, and the flat shape of the "graduated" curve that the observations give for the periods within three or four minutes of totality.

It is unfortunate that the readings were not continued throughout totality, because the residual is surprisingly large and the mid-eclipse values might have been lower.

During the 1922 eclipse, Ross, at Wallal in Western Australia, made photographic exposures to the sky around the south pole, using a camera without a lens. He concluded that, during totality, the sky was as bright as when the sun was 7° 29′ below the horizon.[3] In Canada, when the sun is 7° below the horizon it is impossible to get any reading on the light meter and a brightness of 10 foot-lamberts is generally given for the zenith sky when the sun is not more than 1° 30′ below the horizon.

[2]The factor $\zeta e^{8\zeta}$ has been used to correct for zenith distance, giving the points + of figure 2, whilst for the irregular cloud effect a correction of $1.456 - 0.0076(t - 12h.\ 20m.)$ has been applied to the light values giving the points ×. The circles represent the least scale divisions of the instrument. The correction for zenith distance was suggested by two series of observations made on cloudy days in Canada, the latter is purely empirical. The justification for these assumptions is that they make the observations conveniently symmetrical.

[3]S. A. Mitchell, *Eclipses of the Sun*, p. 347.

A shift in the zero of the instrument is very improbable and it would have affected all the observations equally. The same thing could be said of stray artificial light. This hypothesis leads to an impossible light curve, much too flat for low values of x and giving a limb-darkening law which can not be reconciled with any other observations, even if change of colour is allowed.

The explanation of this difference between the amount of scattered light recorded and the direct light of the crescent sun, whose amount can be calculated from the limb-darkening law for the solar disc, is that stray light has been brought in from other places. The other places from which light can come, either by scattering in the air or reflection from clouds and ground surface, or both, are situated far enough away for the phase of the eclipse to be different.

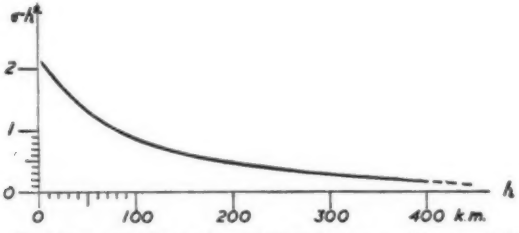

FIG. 3—Scattering of light into shadow in the earth's atmosphere, empirically determined.

By numerical integration it is possible to explore the type of scattering law which will reconcile the data. In this way figure 3 has been produced, giving σh^2 as ordinate against the abscissa h which is the distance from the observer, measured in kilometres over the surface of the earth. Thus, though the scattering function σ decreases rapidly with increasing h, the amount of light contributed from places at great distances is still important. However, for values of h over 200 km. the solution is rather weak and it is impossible to decide from these observations, at what distance σ becomes effectively zero.

This result has been based on an assumed limb-darkening law taken from work published by Lindblad in 1923[4] and extrapolated

[4] *Nova Acta Regiae Soc. Scient. Upsaliensis.* vol. iv, 6. I.

in conformity with a series of direct observations secured by the Dutch observers, at Beloretchenskaia, during the 1936 eclipse.[5]

It would seem therefore that the residual light at inner contact can be explained by scattering in the earth's atmosphere. There is no direct evidence to show at what level this takes place but it would be a reasonable guess to suppose that the light coming from a long way off has been reflected at the upper surface of a sea of clouds and scattered in the air above that level, or perhaps there may have been several reflections from dispersed clouds.

The Australian eclipse was exceptionally long and the sky was cloudless: the place of observation was about a mile from the open ocean, the land covered by a virgin eucalyptus forest, sparse but mingled with low shrubs and grasses. The albedo for reflections from that sort of a surface, must necessarily be very much lower than for reflection from a sea of cloud: therefore the amount of light reflected must have been much less, whilst the larger shadow cone would lead to a still further reduction. Thus it appears to be reasonable to assume that the observations secured in Brazil are not inconsistent with Ross's Australian observations.

Future Work. It would be a comparatively simple matter to arrange a much better programme for any future eclipse. The present results may be of little value in themselves but they do indicate a line of enquiry that might be followed with advantage.

If, from general physical considerations and the extensive work which has been done on atmospheric problems in recent years, a well defined scattering law can be derived, then this sort of investigation might lead to an improved limb-darkening law. There seems to be some need to bridge the gap between the investigations concerning the *extreme* limb, for which the 1936 method gives good results, and direct measurements made on the central portions of the solar disc. To one who has spent much energy endeavouring

[5] *B.A.N.*, vol. III, no. 91.

Since the variation of the scattered light must be asymptotic to the direct light-curve for values of x which are great enough, the graduated curve for the scattered light was fitted tangentially to the latter, coincidence being obtained for values of x between 50 and 70.

Two graduated curves of type $y = a + bx + cx^{3/2} + dx^{5/2}$ were derived by the method of least squares, combining the observations before and after totality, and for the two times of mid-eclipse previously assumed.

to observe eclipses in spite of clouds it is rather intriguing to find a manner in which clouds can actually help.

For a future occasion the following improvements are suggested: (i) Accurate timing, if possible on a continuous record. (ii) A more sensitive instrument with a lower minimum range. (iii) Measurement in two or more colours. (iv) Duplication of the work at different altitudes.

It would not be right to close this report without acknowledgments. To the University of Ottawa for their academic patronage of the undertaking: to the commercial and engineering firms who, at a critical period, got the instruments ready in time: to members of the staff of the Dominion Observatory and of the Canadian Embassy at Rio de Janeiro who aided and advised us and above all to the Government of the State of Minas Gerais, and the many Brazilians, who so lavishly entertained us during our stay in their very beautiful country. Our only regret is that with all this co-operation we were able to do so little.

Ottawa, Ont.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Jean Sylvain Bailly, The Guillotined Astronomer

(concluded from September-October Journal)

After the execution of Louis XVI on January 21, 1793, a wealthy friend tried to persuade Bailly and his wife to sail for England, possibly with America as their ultimate destination. Bailly's sense of patriotism was so strong that he refused to flee from his country. However, on June 30, 1793, Nantes was besieged by eighty thousand Vendeans. Certainly Bailly's life would have been worth nothing had they captured the city, and after they were repulsed Bailly decided it was time to move to one of the quieter, non-insurgent provinces. Until then Mélun had been perfectly tranquil. M. LaPlace was living there in retirement, and had suggested that Bailly and his wife join them. So on the 6th of July M. and Madame Bailly started for Mélun, but unfortunately just as a detachment of the revolutionary army left for that city too. Madame LaPlace immediately wrote a guarded note of warning to Bailly, saying that the house they were intending to occupy was too damp and would be the death of Madame. Imagine then, the consternation of M. and Madame LaPlace when they looked out, about the end of July, and saw Bailly coming up their garden path! The LaPlaces feared that Bailly had missed the meaning of their discouraging letter, but he assured them that he had not; he had come to Mélun in order to have a house of his own in which to be arrested!

He had no chance to enjoy the honour of being a domiciled citizen there, for two days after his arrival he was recognized by a soldier of the revolutionary army and arrested. When the soldier ordered Bailly to accompany him to the town hall, Bailly replied, "I am going there. You may follow me there." The magistrate of Mélun, who was honest and courageous, tried to persuade the people that there was no reason to arrest Bailly, but the most lenient course that he was allowed to follow was to advise Paris of Bailly's whereabouts, meanwhile keeping him under surveillance in his house. At this point Bailly could have escaped, but he refused to do

so, believing it would discolour his own honour and greatly compromise the magistrate M. Tarbé.

The Committee of Public Safety ordered the magistrate of Mélun to transfer Bailly to one of the prisons in Paris. On the day of the transfer Madame LaPlace urged him to escape, but again he refused to do so. Upon his arrival in Paris he was first imprisoned at Madelonnettes, and a few days later at La Force. His wife and nephews were allowed to visit him there. It was from there that he was summoned as a witness in the trial of Marie Antoinette. At this famous trial he defended the Queen, protesting with horror at the slanderous accusations made against her. Because he took this stand, the tribunal viewed him harshly, almost as an accused person rather than as a witness. At this trial Bailly showed his courage and honesty to a marked degree. He might even have bought his own life at this point by siding with the false accusers of the Queen.

After his appearance at this trial Bailly wrote and had circulated a most touching pamphlet (sixteen printed pages) entitled *"J. S. Bailly à ses concitoyens."* In this he sets forth that, contrary to the accusations, he and La Fayette attempted to prevent any escape of the King from the Tuilleries, and that any part which he had in the events on the Champ de Mars was due to his responsibility of office to uphold the laws of the municipality. At the conclusion of his appeal to his fellow-citizens he writes, (*Mém.*, vol. 1, p. 411)

> I have gained by the Revolution only that which my fellow citizens have gained: liberty and equality. I have lost by it some useful situations, and my fortune is nearly destroyed. I could be happy with what remains of it to me and a clear conscience; but to be happy in the repose of my retreat, I require, my dear fellow-citizens, your esteem: I know well that, sooner or later, you will do me justice; but I require it while I live, and while I am yet amongst you. I have deserved it during fifty years of sustained probity; and almost three years of a devotion entirely to your interests, without other price than this esteem, could only increase and consolidate it.

Bailly's own appearance as accused before the Revolutionary Tribunal was set for November 10, 1793. The chief accusations against him were regarding the escape of the royal family, and the catastrophe of the Champ de Mars. We have already discussed these events, and Bailly's probable share in them. Many versions and stories have been given of both of them, so that it is hard to know where the exact truth lies. Certainly Bailly's acts did not

merit a death sentence, but he was unanimously condemned to be executed the following day. When the President of the Tribunal asked him if he had anything to say regarding the sentence, Bailly replied, "I have always carried out the law, I shall know how to submit myself to it, since you are its organ."

Bailly spent the evening of the 11th of November being visited by various comrades, among them his nephew with whom he played a game of piquet. The account given by Arago of the day of his execution is very graphic, and appears reliable in its facts. Various conflicting reports regarding the execution are in existence. We quote from Arago, *op. cit.* p. 157.

> Bailly had risen early, after having slept as usual, the sleep of the just. He took some chocolate, and conversed a long time with his nephew. The young man was a prey to despair, but the illustrious prisoner preserved all his serenity. The previous evening in returning from the Tribunal, he remarked, with admirable coolness, though springing from a certain disquietude, "that the spectators of his trial had been strongly excited against him. I fear," he added, "that the mere execution of the sentence will no longer satisfy them, which might be dangerous in its consequences. Perhaps the police will provide against it." These reflections having recurred to Bailly's mind on the 12th, he asked for, and drank hastily, two cups of coffee without milk. These precautions were a sinister omen. To his friends who surrounded him at this awful moment, and were sobbing aloud, he said, "Be calm; I have rather a difficult journey to perform, and I distrust my constitution. Coffee excites and reanimates; I hope, however, to reach the end properly."
>
> Noon had just struck. Bailly addressed a last and tender adieu to his companions in captivity, wished them a better fate, followed the executioner without weakness as well as without bravado, mounted the fatal cart, his hands tied behind his back. Our colleague was accustomed to say: "We must entertain a bad opinion of those who, in their dying moments, have not a look to cast behind them." Bailly's last look was towards his wife. A gendarme of the escort feelingly listened to his last words, and faithfully repeated them to his widow. The procession reached the entrance to the Champ de Mars, on the side towards the river, at a quarter past one o'clock. This was the place where, according to the words of the sentence, the scaffold had been raised. The blinded crowd collected there furiously exclaimed that the sacred ground of the Champ de la Fédération should not be soiled by the presence and by the blood of him whom they called a great criminal. Upon their demand (I had almost said their orders), the scaffold was taken down again, and carried piece-meal into one of the fosses, where it was put up afresh. Bailly remained the stern witness of these frightful preparations, and of these infernal clamours. Not one complaint escaped from his lips. Rain had been falling all the morning; it was cold; it drenched the body, and especially the bare head, of the

venerable man. A wretch saw that he was shivering, and cried out to him, *"Thou tremblest, Bailly." "I am cold, my friend,"* mildly answered the victim. These were his last words.

Bailly descended into the moat, where the executioner burnt before him the red flag of the 17th July; he then with a firm step mounted the scaffold. Let us have the courage to say it,—when the head of our venerable colleague fell, the paid witnesses whom this horrid execution had assembled on the Champ de Mars burst into infamous acclamations.

Thus ended the life of a man who was years ahead of his time in thought and outlook.

After her husband's death, Madame Bailly was a crushed soul, living for some time in poverty. To add to her pitiful situation was the fact that she had placed 30,000 francs from the sale of the house at Chaillot in the wadding of a dress, and forgot the whereabouts of the money, though she was in great need, until it was no longer of value. Brighter days came to her later, after the appointment of General Bonaparte as Consul and M. de LaPlace Minister of the Interior, when a pension of 2000 francs was granted her, with the Consul demanding that the first half year should be paid in advance, and at once. Mme. de LaPlace had then the overwhelming pleasure of calling upon the pathetic widow to bring her a purse full of gold.

In preparation of this account of the life of Jean Sylvain Bailly, I have been fortunate in having access to several thousand pages of Bailly's writings in their original editions, in the library of the University of Toronto. These comprise the volumes of the *Histoire de l'Astronomie,* as well as the three memorable volumes *Mémoires d'un Témoin.* The long biography written by Arago has also been very helpful, as well as the comprehensive sketch of Bailly's life in the ninth edition of the Encyclopaedia Brittanica, 1875. In most of the summaries or histories of astronomy which have been published in English during the last century, references to Bailly are sadly lacking. In summarizing his life I have tried always to select the most reliable version of an incident. As I have followed through the course of his amazing existence, with his steady climb upward in public recognition and in achievement, a climb attended with burdens and problems almost unbearably heavy, the words of the ancient poet have kept flitting through my mind, "Let us now praise famous men."

REVIEW OF PUBLICATIONS

The Conquest of Space, by Chesley Bonestell and Willy Ley. Pages 160. Macmillan Co. of Canada Ltd., Toronto. 1949. Price, $3.95.

This is a very beautiful book which will make the eyes of every red-blooded boy pop with wonder and excitement. Indeed it will do the same for any grown-up who hasn't lost whatever it is that makes boys' eyes pop. For here is the kind of beautiful coloured pictures about astronomy that, until now, only the French books have given us: pictures of lunar landscapes during an eclipse of the sun by the earth, of the rising earth seen from within a lunar valley, of Mars seen from Deimos, of Saturn looming over the snowy wastes of Titan.

The Conquest of Space is essentially a picture book with appropriate text. The pictures are by Bonestell, the text by Ley. Bonestell is apparently well known to devotees of science fiction; for the sake of the rest of us Ley provides an introduction. It seems that Bonestell is by training an architect and an artist who has specialized in representing how things will look under a specified set of circumstances. So, "if Titan is so and so many miles from Saturn, and Saturn is so many miles in diameter, with the plane of rings inclined so and so many degrees—what will be the result? The result is Plate XXXVI." Ley himself is known to recent readers of this JOURNAL as an authority on rockets and an enthusiastic prophet of the imminence of interplanetary travel.

So the two of them take us away from the earth and, as Ley gives us a brief résumé of his views on rockets and rocket travel, Bonestell shows us pictures of how the earth will look from various heights above its surface. As Ley describes our sensations on a rocket trip to the moon, Bonestell shows us lunar landscapes, space explorers setting up the first lunar base, etc. As Ley goes on to describe the known facts and the conjectures about the planets and their satellites, Bonestell follows along with his spectacular views of these bodies.

Without wishing to appear flippant, the present reviewer would like to express the view that all this is good clean fun providing the reader accepts it as such. He must understand, though, that this sort of book adds nothing to astronomical knowledge. The details which Bonestell works into his paintings are Bonestell's renderings of a blend of real facts, reasonably certain conclusions and rather shaky conjectures on the part of the astronomers with a few unjustified extrapolations by the artist thrown in. (How, for example, does Bonestell justify his fire and brimstone picture of Jupiter with "hydrogen flames and lava" pouring over a cliff of lava and ice into a lake of liquid ammonia?)

More than half of Ley's text is astronomical. He represents astronomy as falling into three phases: the pre-telescopic or historical phase, the telescopic or present phase and the go-there-and-see or immediate future phase. In a most vivid way he describes the discoveries of the past and the puzzles of the present and then dumps them into the lap of the future. Ley writes extremely well about these topics, but sometimes one wishes he weren't quite so arbitrary (as in his so emphatic rejection of the volcanic theory of the origin of lunar craters) and at other times that he weren't quite so easily impressed (as with his apparent whole-hearted acceptance of the existence of changes on the moon and canals on Mars).

To hark back to the red-blooded boy mentioned at the beginning of this review, the grave danger of a book like this is that when this same boy, ten years hence, visits an observatory and is shown Jupiter through a large telescope he may, for some reason which he perhaps has forgotten, be vaguely disappointed. It is one thing to stimulate the imagination, it is another thing to intoxicate it.

J. F. H.

Scientific Autobiography and other papers, by Max Planck, 192 pages, 5 × 8 in. New York, Philosophical Library, 1949. Price $3.75.

The chapter entitled "Scientific Autobiography" occupies 39 of the 192 pages of this book. In it one of the greatest of modern scientists describes how he became a theoretical physicist and how through continued logical reasoning, checked by experimental measurement, one of the most important fundamental laws of physics was established.

Planck's original decision to devote himself to science (he tells us) came from his comprehension that the laws of human reasoning coincide with the laws governing the impressions we receive from the world about us. This fact is not at all self evident. He concluded that there must be something *absolute*, and to him the quest for it was the most sublime scientific pursuit in life.

The first law which seemed to have absolute universal validity, independently of all human agency, was the principle of the conservation of energy. With this Planck was powerfully impressed. He was born in 1858, and at that time much effort was being devoted to establish this great principle, and in doing so the subject of thermodynamics was developed in a logical form. Planck's studies were largely related to this subject. Planck describes in detail how he was led from one problem to another and how his views on various questions altered. His association with Helmholtz powerfully affected him.

The present reviewer was interested to learn that Planck's first task after appointment in the University of Berlin was to use a large harmonium of pure untempered tuning to study the natural or untempered scale and he found that "the tempered scale was positively more pleasing to the human ear, under all circumstances, than the natural untempered scale."

Another fact he says he learned was, "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

Planck's celebrated law, which enunciated the Quantum Theory, was given to the world in 1900. According to it the energy of radiation is emitted in definite small "parcels" or quanta, not continuously, as was considered in the wave theory. Planck's views on the Theory of Relativity are also explained and he shows that it is based on something absolute.

The other papers in this volume are: Phantom problems in science (1946); the meaning and limits of exact science (1941); the concept of causality in physics; religion and natural science (1937). They were public lectures delivered in the years indicated. Planck died in October, 1947.

The translation into English, especially of the autobiographical chapter, is of superior quality.

C. A. C.

Tycho Brahe's Description of his Instruments and Scientific Work, as given in *Astronomiae Instauratae Mechanica* (Wandesburgi 1598), translated and edited by Hans Raeder, Elis Strömgren and Bengt Strömgren. Copenhagen, 1946.

Tycho Brahe (1546-1601) is one of the most picturesque figures in the history of astronomy. He was born in Knudstrup in Scania, then a part of Denmark, now a southern province of Sweden. He was one of the nobility, which fact he seemed never to forget. He studied in Copenhagen, Leipzig, Rostock and Augsburg.

Tycho was the oldest of five sons, and his paternal uncle, having no children of his own, took charge of him when he was a child and brought him up. This uncle allowed him to establish a laboratory in his castle near Knudstrup in 1571, and while there, on Nov. 11, 1572, he discovered his "new star" in Cassiopeia. He became quite famous, and by royal command, delivered lectures in Copenhagen. He states that he was seriously considering settling in the town of Basel, "there to lay the foundation of the revival of Astronomy."

> But it so happened that while I was inwardly contemplating these matters and was already making preparations for the journey, without however revealing my purpose, the noble and mighty Frederick II, King of Denmark and Norway, of illustrious memory, sent one of his young noblemen to me at Knudstrup with a Royal letter bidding me to see him immediately wherever he might be dwelling on Sealand. When I had presented myself without delay this excellent King, who cannot be sufficiently praised, of his own accord and according to his most gracious will offered me that island in the far-famed Danish sound that our countrymen call Hven, but which is usually called Venusia in Latin, and Scarlatina by foreigners. He asked me to erect buildings on this island, and to construct instruments for astronomical investigations as well as for chemical studies, and he graciously promised me that he would abundantly defray the expenses. (p. 109)

The first stone of his great observatory Uraniborg was laid on Aug. 8, 1576, and there he laboured incessantly for 21 years. He had a large number of helpers, including students who lived in his house all the time and who "distinguished themselves by talents and a keen vision". But King Frederick's successor was not so tolerant of Tycho's foibles and imperious demands, and cut off his support. This brought Tycho's labours on Hven to a halt, and he sailed for Rostock in 1597.

In 1598 Tycho published *Astronomiae Instauratae Mechanica* and not many copies were printed. In 1901, the tercentenary of his

birth, a facsimile edition was published; and in the "Opera Omnia" edition of Tycho's works prepared by J. L. E. Dreyer it is included in volume V. These editions are all in Latin.

In celebration in 1946 of the 400th anniversary of Tycho Brahe's birth, the Royal Danish Academy of Sciences and Letters decided to publish an English translation of this work. It contains 144 quarto pages and the paper and typography are excellent. The translation is scholarly and of course scientifically accurate. It is a pleasure to read Tycho's own account of his extraordinary collection of instruments, designed by himself and constructed on his own premises—evidently with enormous labour and expense.

In almost every printed sketch of Tycho's life there have been pictures of some of these instruments and many readers have wondered how they were used. In the present publication there is, first of all, a portrait of Tycho in his lordly robes, and then 32 figures. Four are of his buildings, one of his island, and the majority of the rest are full-page cuts of the instruments. Tycho fully appreciated the need of accuracy in his measurements, and he lived before the invention of the telescope. His work was exclusively in the astronomy of position. His sextants and quadrants were used to determine the altitude and azimuth of the heavenly bodies, while with the assistance of his armillary spheres he determined celestial longitude and latitude, and also right ascension and declination. By making his instruments large and graduating them accurately he was able to take readings to ten seconds of arc. He speaks of measuring the altitude of a star with three of his quadrants and obtaining the same result "within an insignificant fraction of a minute of arc." The radius of the arc in these three instruments was 194 cm., or 6 ft. 6 in., in two of them, and 155 cm., or 5 ft. 2½ in., in the third one.

The next-preceding great name in astronomy was that of Copernicus, who was born in 1473 and died in 1543, three years before Tycho was born. Tycho has some interesting references to him. In describing the "Parallactic or Ruler-instrument" (Fig. 9) he says:

> An instrument of this kind has come into my possession, made entirely of wood, which previously belonged to the incomparable Copernicus, and was even, it was said, made by him with his own hand. It was sent to me as a

gift from Master Johannes Hannow, a canon from Ermeland, where Copernicus used to live, and where in the year 1584 I had sent one of my collaborators . . . with a sextant . . . that he should measure, as accurately as possible, the altitude of the pole; for I supposed that the value of this quantity determined by Copernicus was nearly three minutes too small. That such was the case was confirmed by observation. When my collaborator came back to me, he brought with him not only the sextant with which I had provided him, but also this other parallactic instrument of Copernicus' as a gift from the canon mentioned. (p. 45)

In describing his observations of Mercury Tycho says:

In fact we observed it carefully almost every year, in the morning as well as in the evening. And yet the great Copernicus cites as an excuse for his not having observed it the far too high latitude and the mists of the river Vistula. We however, at a still higher latitude, and on an island surrounded on all sides by a misty sea, have seen it many times, as I said, and determined its position. But perhaps the house where Copernicus lived was not located in such a way that the horizon was free in all directions, and therefore was not quite suitable for making observations, especially at such a low altitude. (p. 110)

Reference should also be made to Tycho's Great Brass Globe (Fig. 22). Inside it was built of wood but finally the surface was covered with brass, the joining of the sheets being hardly visible. It was about six feet in diameter, and, quoting Tycho again,—

Thus about 25 years elapsed from first beginning to make this globe until its completion, both as regards its divisions and its stars. Although this long interval of time may seem annoying, it has, nevertheless, been of no little advantage by making it possible to complete the whole work with so much the greater certainty, perfection, and accuracy. If it has been done well enough it has also been done quickly enough. (p. 104)

I wonder what became of that sphere?

C.A.C.

NOTES AND QUERIES

Bright October Meteors Over Ontario

After press and radio had reported an unusual flash in the sky just after midnight on October 14, the David Dunlap Observatory asked for first-hand accounts from persons who had seen the phenomenon. As a result of this appeal about 75 reports were received. Of these, about 50 referred to the October 14th phenomenon, which appeared to be a meteor of the fireball class. Represented among the remaining 25 reports were at least five other meteors seen during October; these also seem to have been bright enough to deserve the name of fireball. Since this appears to represent an unusually high frequency of bright meteors, it may be of value to record the principal features reported about these meteors.

October 14, 0008 E.S.T.

The October 14 fireball was the best reported of the lot. Reasonably good observations were received by mail from observers in and near Toronto, Windsor, Beaverton, Jordan, Port Carling, Sudbury and Larder Lake. Circumstances did not permit the following up of these reports by on-the-spot interviews, and accordingly the numerical data are not considered accurate enough to warrant a careful solution of the path. However, the best observations yield the following estimates:

Illuminated path was over the region of 47° N 81° W. Direction of motion was southward. Heights (uncertain): beginning 110 miles, end 45 miles. Duration of meteor itself was probably not more than 4 seconds. One burst occurred about two-thirds way along the path; magnitude at this time is estimated as -10. From the region of the burst onwards a persistent train appeared which was thicker at the beginning than at the end. This was prominent for five minutes and was observable under good conditions for a further ten minutes. The train was seen to twist into an S-shape by observers in Northern Ontario to the east of it and was seen to grow gradually wider by observers to the south. Reports of colour changes in the train are conflicting.

October 4, 0300 E.S.T.

From near Guelph one observer reported seeing a meteor in the west which lit up the sky for a few seconds almost as daylight.

October 9, 0500 E.S.T.

From Whitefish Lake, about 50 miles west of Port Arthur, a meteor was seen which was bright enough to light up the surrounding hills. Two observers (who were together) reported seeing this meteor.

October 19, 1900 E.S.T.

A very bright meteor of magnitude −4 or better was reported by three independent observers at Harriston, Midland and North Cobalt. As seen from North Cobalt the meteor passed approximately through the zenith, going from east to west. It left a train visible for three seconds or more.

October 26, 1931 E.S.T. and 2050 E.S.T.

The press reported spectacular meteors on this night seen mostly from Buffalo and district. Two astronomers on duty at the David Dunlap Observatory reported seeing the one at 1931 E.S.T., estimating its brightness as being about that of the cresent moon. Its path was low in the east and vertical towards the horizon.

The meteor at 2050 E.S.T. was reported by four observers in the Toronto area. It was low in the south-east and it was bright enough to light up the clouds on the southern horizon.

J. F. H.

Victoria Centre's "Brydon" Telescope

At a meeting of the Victoria Council, R.A.S.C., November 1, 1949, it was decided to change the name of the Centre's telescope from the "Wray" telescope to the "Brydon" telescope. The 4-inch refractor which has been described in the Journal,[1] has been in the possession of the Society since 1944 being acquired at that time from Mr. H. Boyd Brydon, a valuable and esteemed member of the Centre and the 1941 winner of the Chant Medal. The instrument was originally owned by Mr. A. F. Miller of Toronto

who was one of the charter members of the Royal Astronomical Society of Canada.

The telescope was housed for many years in Mr. Brydon's Oak Bay Observatory and after its purchase by the Society, Mr. Brydon kindly allowed it to remain there for the use and enjoyment of the members of the Centre. When, in April, 1947, the property on which the dome rested was sold to Mr. E. L. Elias, he and Mr. Brydon generously gave Victoria Centre possession of the building for assuming the responsibility for moving it. Under the capable supervision and cooperation of Messrs. Pope, Jervis and others the building and telescope were transported several miles to the grounds of Mr. Robert Peters' home in Gordon Head, on the outskirts of Victoria. There, under the friendly and efficient supervision of Mr. Peters, Director of Telescopes for the Centre, members of the society and their interested friends have been privileged to observe many objects in the heavens.

Dominion Astrophysical Observatory,
November 15, 1949.

Four Eclipses in one Evening

On the evening of September 24, 1949, Jupiter and three of his satellites staged four eclipses—two total solar eclipses, a total lunar eclipse and a partial lunar eclipse—a rather unusual series of events. We observed these at Toronto. The satellites which were involved were Io, Europa and Ganymede.

When the sky darkened this evening, the shadow of Ganymede was already on Jupiter, and Io was in the planet's shadow. At 6.37 p.m. Eastern Standard Time, the shadow of Europa ingressed on Jupiter and then, for a period of two hours and forty-seven minutes, the two shadow dots were observed as they crossed the planet, the black shadow of Ganymede, the larger satellite, being much darker and more clearly seen than that of Europa which followed it. These shadows were evidence of two total solar eclipses.

As these two shadow dots progressed, however, that of Europa could be seen creeping closer to Ganymede's shadow, and moving directly towards it, and when they were quite close to each other it appeared that these shadows would coincide, which would mean that

Europa itself would be eclipsed by Ganymede, and possibly would even disappear for a short period. This prospect added considerable interest to the observations.

At about 9.00 p.m., and for a period of about ten minutes, the brightness of Europa did appear to us to be very much reduced, but this satellite was still visible, and it then regained its former brightness. We are sure, therefore, that we witnessed a partial eclipse of Europa by Ganymede—the partial lunar eclipse in these observations.

At 9.30 p.m. Io emerged quickly from the shadow of Jupiter—at considerable distance from the planet, possibly forty per cent. of its diameter—thus completing the total lunar eclipse. This eclipse reappearance of the satellite out in space was much more interesting than occultation reappearances which always occur at the edge of the planet.

At 9.24 and 9.26, respectively, the shadows of Europa and Ganymede egressed from Jupiter's disc—thus showing that the former had overtaken the latter and passed it, in which passing the partial lunar eclipse of Europa had occurred. The egression of these shadows from the planet completed the two solar eclipses.

As the reappearance of Io and the egression of the shadows of Europa and Ganymede occurred at almost the same time, the apparent distances of these satellites from the nearest edges of Jupiter would just then be in practically the same relation as the actual radial distances of these satellites from the centre of the planet—thus we had an excellent opportunity to compare their radial distances as the concluding feature of these interesting observations.

The fourth visible satellite, Callisto, did not take part in the eclipses on that evening. It was too far east of the planet.

F. K. Dalton

MEETINGS OF THE SOCIETY

AT TORONTO

October 25, 1949—The second meeting of the autumn session was held in the McLennan Laboratory, with Mr. A. R. Clute presiding.

Twenty-nine applicants for membership, nominated at the meeting on October 11th, were elected.

Five new applicants for membership were nominated as follows:

Dr. Wm. Pierce Ellis, Veterinary Surgeon, Holstein
Mr. J. A. Langford, 141 Brookdale Ave., Toronto
Mr. William C. Shaw, Galt Street, Hespeler
Mr. Lawrence Weller, 264 Grace Street, Toronto
Mr. Thomas A. Wood, 98 Spruce Street, Toronto

The Secretary announced that the Hamilton Centre has donated a Spitz Planetarium to McMaster University, Hamilton, and has invited Toronto members of the Society to the formal opening on November 5th, when there will be a lecture and demonstration by the designer, Mr. Armand N. Spitz, the Franklin Institute, Philadelphia, and also a new film, "The Story of Palomar", will be shown.

Mr. Clute then called upon Dr. P. M. Millman of the Dominion Observatory, Ottawa, to speak on the subject: "Seeing Meteors by Eye, Camera and Radio". Dr. Millman stated that during the past two and a half years astronomers and radio physicists have been applying several techniques to the study of meteors. In this work, the Dominion Observatory and the National Research Council have co-operated closely, the former carrying out the visual and photographic part of the investigation while the latter directed the radar and radio observations. This is an extensive program and the Canadian Government is supporting meteor research very handsomely.

The speaker explained that a meteor is a small mass moving at high speed and developing light, heat and electrical charges as it passes through the earth's atmosphere. Study of the upper atmosphere will be very important in the future. He then described the four techniques now being applied, namely—visual and photographic methods, radar and radio—showing by slides some of the results obtained in each case.

Visual Observation—using the light from the meteor. About 7000 meteors have been observed. The equipment in use was illustrated and the method of observation explained. This means gives fairly accurately the position, direction and time of appearance.

Photography—obtaining a permanent record by camera. About 150 meteors have been photographed. A special segmented shutter is used to measure the speed of the meteor, showing the trail as a dotted line. Two

similar cameras, spaced a distance apart, will give the height of the meteor and the combined results also give the actual speed. The camera gives information similar to that obtained by visual observation but does so more accurately. By the use of the spectrograph, photographic records give the colour, and changes in colour of a meteor.

Radar—sending out a radio pulse signal, then receiving and recording the waves reflected from the meteor and its electrically charged path. About 2,000,000 meteors have been observed by this means. The equipment consists of a transmitter and a receiver with aerials known as the "folded dipole", about fifteen feet long. The radio frequency of 30 megacycles per second is used, with 120 pulses per second. The received signals are shown by a cathode ray tube and photographed on a motion picture film. This film makes a trace of the reception giving distance and travel of the meteor. Radar equipment is set up at three points in a triangle to determine definitely the position of the meteor. In this work the equipment used must be of very high quality in order to produce good results. The illustrations showed remarkable radar reception from meteors, the record of travel being plainly evident and the continuation of the charge, following the passage of the meteor, also being shown.

Radio—sending continuous-wave signals which are reflected from the meteor and received together with a wave direct from the transmitter. The interference of these waves gives a varying beat note, or Doppler effect, which by change of frequency indicates whether the meteor is approaching or receding. This signal can be heard as one of changing pitch, like the whistle of a passing train, or recorded photographically from a cathode ray tube by moving film whereby the frequency variations may be seen. By interpretation of the wave recorded on the film the velocity of the meteor toward or away from the observation station can be determined. About 50,000 meteors have been recorded by this method. By slides, records were shown on which the varying frequency could be measured.

The speaker then showed records of one meteor, by the four techniques in use, this being the most completely recorded meteor to date. From these, the height and position had been computed and all records agree very well as to direction of travel and mean velocity. The photographic method indicated that the meteor appeared at a height of 115 kilometers above the surface of the earth whereas by radar it appeared at 90 kilometers. Both methods agree that it died out at a height of 65 kilometers. The results will give the orbit very accurately when computation are complete.

Dr. Millman said that other methods of investigations are being planned and those now in use are being improved.

In moving a vote of thanks to the speaker, Dr. F. S. Hogg pointed out the very high quality of the records shown by the slides.

November 8, 1949—A meeting of the Toronto Centre was held in the McLennan Laboratory at 8:00 p.m. Mr. A. R. Clute presided.

Five applicants for membership, nominated at the meeting on October 25th, were elected. Four new applicants for membership were nominated, as follows:

Miss Helen M. Cromeeke, 3 Bedford Rd., Toronto 5
Mr. Owen Hughes, 659 Yonge St., Toronto 5
Mr. Norman F. Sherwood, 3112 Yonge St., Toronto 12
Mr. Clarence Wallace, 51 Runnymede Rd., Toronto 9

Upon motion of the Secretary, and with the approval of the members present, the Nominating Committee, for nomination of officers for 1950, was elected, consisting of Dr. J. F. Heard, Mr. H. W. Barker and Miss Ruth J. Northcott. The Recorder read a news release, dated October 22nd, from the California Institute of Technology which gave interesting information about the Palomar telescope, stating the inconceivable distances and sizes of objects now seen or photographed for the first time.

This was followed by a very informative sound and colour film, "The Story of Palomar", which explained the optical principles and illustrated some features in the design, construction, installation and operation of the new 200-inch Hale telescope at Palomar Mountain Observatory, showing a few photographs of celestial bodies to emphasize the advantages of so large an instrument.

Mr. Clute expressed the thanks of the meeting to the Secretary for having procured the film for this occasion. As the attendance was very much greater than the room provided could accommodate, it was necessary to show the film twice. During the second showing, members who by then had seen it, gathered in another room where Mr. T. A. Matthews explained many terms used in astronomy, how telescopes operate and some of the information obtained by means of them, and answered questions asked by members.

Following the second run of the film, the meeting was adjourned.

F. K. DALTON, *Recorder.*

AT QUEBEC

8 Octobre 1949.—La réunion mensuelle du Centre de Québec de la R.A.S.C. eut lieu à l'observatoire de la société, sous la présidence de M. G.-E. Gagné, président actuel.

La conférence—Apparences ou Réalités—fut donnée par M. Jean-Pierre Bernier, étudiant en physique. C'était un bref exposé qualitatif de ce qu'il est possible d'observer chaque jour, chaque nuit, chaque année. Il s'agissait seulement de prendre contact avec les principaux phénomènes célestes et de voir comment ils nous apparaissent. L'observation immédiate nous fait croire à l'existence d'une voûte céleste, puis à celle d'une sphère céleste en considérant le mouvement diurne des étoiles. Ces dernières semblent entrainées par cette sphère, alors que d'autres corps, tels le Soleil, la Lune, les planètes paraissent se déplacer sur sa surface intérieure. Le conférencier a décrit le mouvement annuel du Soleil et les mouvements bizarres des planètes parmi les étoiles, de même que les phases de la Lune. Certaines définitions essentielles furent aussi données: sens direct, sens rétrograde, équinoxes,

solstice, écliptique, zodiaque, opposition, conjonction, quadrature, période, etc. La conférence avait pour but de poser ce problème: les mouvements observés sont-ils réels ou apparents? Comment les expliquer? La réponse à ces questions fut l'objet de la réunion suivante.

12 Novembre 1949—Samedi le 12 novembre 1949, eut lieu à l'amphithéâtre de physique de l'Université Laval la réunion mensuelle de la société. M. Claude Frémont, vice-président de la société, agissait comme président de la réunion.

M. R. Vaillancourt, étudiant à la Faculté des Sciences de l'Université Laval, rappela comment fixer la position d'un point sur la Terre à l'aide de deux coordonnées, la latitude et la longitude, puis comment, une fois la position de l'observateur connue, déterminer cells des astres, soit dans un système de coordonnées locales, soit dans un système de coordonnées équatoriales.

M. Jean-Pierre Bernier parla ensuite des "Systèmes planétaires". Avant l'éveil de la pensée grecque, on ne se fiait qu'au témoignage trompeur des apparences. Les idées dominantes des systèmes grecs sont: les astres sont des corps sphériques, exécutant des mouvements circulaires et uniformes. Le système qui eut le plus de vogue fut celui de Ptolémée, savant grec professant à Alexandrie vers 140 de notre ère. Son système est géocentrique, expliquant les mouvements des planètes par l'emploi des épicycles. Puis en 1543, parut l'oeuvre de Copernic, qui marque le début des temps modernes en Astronomie. Le système de Copernic est héliocentrique. La Terre n'est plus qu'une planète tournant sur elle-même: le mouvement diurne des étoiles et les mouvements des planètes s'expliquent facilement. Il y eut aussi le système de Tycho-Brahé, qui fut l'un des plus grands observateurs. Puis le conférencier, après avoir rappelé quelques notions sur l'ellipse, énonça les trois lois de Képler et montra comment, à l'aide de la troisième, il est possible de construire un petit système solaire à l'échelle. Il termina en exposant la loi de la gravitation universelle de Newton, qui explique les faits que les lois de Képler décrivent, et justifia cette loi en calculant de combien la Lune tombe vers la Terre dans une minute de chute. On indiqua aussi brièvement combien cette loi était féconde en Mécanique Céleste.

JEAN-PIERRE BERNIER

INDEX TO VOLUME XLIII, 1949

INDEX TO VOLUME XLIII, 1949

A

American Astronomical Society: Eighty-first Meeting, *C. A. Chant*, 138.

Astronomer Royal Visits the United States, The, 208.

Astronomie, L', 124.

Aurigae, The Extent of the Chromosphere of the K-type Component of Zeta, *H. L. Welsh*, 217.

Aurigae, 1946-1948, The Spectrum of Epsilon, *K. O. Wright* and *Elsa van Dien*, 15.

B

Baglow, R. L. (see Review of Publications).

Bailly, Jean Sylvain, The Guillotined Astronomer, 117, 195, 237.

Blüh, Otto, The Galaxies and Time, 169.

C

Calendar that we Need, The Perpetual World, *Conrad M. Morin*, 181.

Campbell, J. W., The Universe—Whence?, 49.

Cephei from Lines of Different Chromospheric Levels, Radial-velocity Curves for Delta, *T. S. Jacobsen*, 142.

Chant, C. A., American Astronomical Society: Eighty-first Meeting, 138; (see also Notes and Queries and Review of Publications).

Chromosphere of the K-type Component of Zeta Aurigae, The Extent of the, *H. L. Welsh*, 217.

Covington, A. E., Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters (with W. J. Medd), 106.

D

Dalton, F. K., Star Diagonals on Finder Telescopes, 34 (see also Notes and Queries).

David Dunlap Observatory, Communications, No. 18, *Sawyer*, 38; No. 22, *Heard*, 149.

Dominion Astrophysical Observatory, Contributions, No. 17, *Wright* and *van Dien*, 15; No. 18, *Jacobsen*, 142; No. 21, *Welsh*, 217.

Dominion Observatory, Contributions, Vol. 2, No. 4, *Stewart*, 129.

Douglas, A. Vibert, International Astronomical Union, 1948, 61.

E

Earth, Gravity in the Interior of the, *R. Meldrum Stewart*, 129.

Earthquake Observation by Transit Telescope, Time Service Notes:, 211.

Eclipse at Araxa, Brazil, 1947 May 20, Observations of the Total Solar, *James Hargreaves*, 229.

Eclipses in One Evening, Four, 249.

Extent of the Chromosphere of the K-type Component of Zeta Aurigae, The, *H. L. Welsh*, 217.

F

Fireball in the Bruce Peninsula, Detonating, 122.

Fireball of April 3, 1949, The, *John F. Heard*, 149.

G

Galaxies and Time, The, *Otto Blüh*, 169.

Gilchrist, Lachlan, The Lure of Underground Treasures, 97.

Globular Clusters, The Early Discovery of Four, 45.
Globular Clusters, Two RV Tauri-type Variables in, *Helen B. Sawyer*, 38.
Gravity in the Interior of the Earth, *R. Meldrum Stewart*, 129.
Guimont, J. E. (see Notes and Queries).

H

Hargreaves, James, Observations of the Total Solar Eclipse at Araxa, Brazil, 1947 May 20, 229.
Heard, John F., The Fireball of April 3, 1949, 149; (see also Notes Queries and Review of Publications).
Hogg, F. S. (see Notes and Queries and Review of Publications).
Hogg, Helen Sawyer (see Out of Old Books and also under Sawyer, Helen B.)

I

International Astronomical Union, 1948, *A. Vibert Douglas*, 61.

J

Jacobsen, T. S,, Radial-velocity Curves for Delta Cephei from Lines of Different Chromospheric Levels, 142.

L

Lectures before the Society:
EDMONTON CENTRE—Problems of Space Travel, *J. W. Campbell*, 96; A Trip to Mars, *David Kinlock* and *Peter Crockford*, 162; Radar and its Uses, *G. W. Paul*, 162; Lunar Mountaineering, *Rex Gibson*, 163; Comets, *Mr. Sheffield*, 163; Electromagnetic Radiation, *E. H. Gowan*, 164; Stargazing, *S. Tweedie*, 164.
MONTREAL CENTRE—Observation of Total Lunar Eclipse on April 12-13, 1949, 125.
OTTAWA CENTRE — International Meetings, *C. S. Beals*, 165.
QUEBEC CENTRE — Apparences ou Réalités, *Jean-Pierre Bernier*, 253; Systèmes Planétaires, *Jean-Pierre Bernier*, 254.
SASKATOON CENTRE—International Union of Geodesy and Geophysics, *Dr. Currie*, 95; Nuclear Physics, *Dr. Harrington*, 96.
TORONTO CENTRE — Sir William Herschel, *C. A. Chant*, 94; North Magnetic Pole, *Paul H. Serson*, 95; Bode's Lost Planet, *C. A. Bauer*, 95; Radio Waves from Sun and Stars, *Ralph E. Williamson*, 165; Time—how we find it and how to use it, *R. W. Tanner*, 167; Recent Studies of the Aurora Borealis, *C. W. Gartlein*, 167; Telescopes—their why and how, *Raymond E. Pearce*, 213; New Telescopes and the Milky Way, *Donald A. MacRae*, 214; Eclipses and Occultations, *Miss Ruth Northcott*, 215; "Seeing" Meteors by Eye, Camera and Radio, *P. M. Millman*, 251.
WINNIPEG CENTRE—Optical Instruments, *H. Rasmussen*, 212.
Loon's Necklace, The, 209.
Lure of Underground Treasures, The, *Lachlan Gilchrist*, 97.

M

Medd, W. J., Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters (with A. E. Covington), 106.
Meteors over Ontario, Bright October, 247
Mirror, Perfecting the 200-inch, 123.
Morin, Conrad M., The Perpetual World Calendar that we Need, 181.

N

Notes and Queries, 122, 161, 208, 247.
Nova in Scutum, 161.

O

Observations of the Total Solar Eclipse at Araxa, Brazil, 1947 May 20, *James Hargreaves*, 229
Observatories in Canada, Amateur, 161.
Out of Old Books, 45, 117, 195, 237.

P

Perpetual World Calendar that we Need, The, *Conrad M. Morin*, 181.
Petrie, R. M., Some Problems of Stellar Motions, 1.

R

Radial-velocity Curves for Delta Cephei from Lines of Different Chromospheric Levels, *T. S. Jacobsen*, 142.
Radio Noise in 1.5 Meters and 10.7 Centimeters, Simultaneous Observations of Solar, *A. E. Covington* and *W. J. Medd*, 106.
Review of Publications:
Becvar, A., Skalnate Pleso Atlas of the Heavens, *J.F.H.*, 111.
Bonestell, Chesley, and Willy Ley, The Conquest of Space, *J. F. H.* 241.
Chant, C. A., Our Wonderful Universe, *F.S.H.*, 207.
Guth, V., Gnomonicky Atlas Hvezdne Oblohy, *J.F.H.*, 113.
Harvard Observatory Monographs, no. 7, Centennial Symposia, *F.S.H.*, 93.
Mayall, R. Newton, and Margaret L. Mayall, Skyshooting (hunting the stars with your camera), *F.S.H.*, 204.
Menzel, Donald H., Our Sun, *F.S.H.*, 205.
Moore, Charlotte E., Atomic Energy Levels, volume 1, *J.F.H.*, 206.
Planck, Max, Scientific Autobiography and other papers, *C.A.C.*, 242.
Raeder, Hans, Elis Strömgren and Bengt Strömgren, translators and editors, Tycho Brahe's Description of his Instruments and Scientific Work, *C.A.C.*, 244.
Russell, Bertrand, Human Knowledge: its Scope and Limits, *R. L. Baglow*, 114.
Royal Astronomical Society of Canada, Annual Meeting, 66.

S

Sawyer, Helen B., Two RV Tauri-type Variables in Globular Clusters, 38 (see also under Hogg, Helen Sawyer).
Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters, *A. E. Covington* and *W. J. Medd*, 106.
Sky Survey, 122.
Solar Eclipse at Araxa, Brazil, 1947 May 20, Observations of the Total, *James Hargreaves*, 229.
Solar Radio Noise on 1.5 Meters and 10.7 Centimeters, Simultaneous Observations of, *A. E. Covington* and *W. J. Medd*, 106.
Some Problems of Stellar Motions, *R. M. Petrie*, 1.
Spectrum of Epsilon Aurigae, 1946-1948, The, *K. O. Wright* and *Elsa van Dien*, 15.
Star Diagonals on Finder Telescopes, *F. K. Dalton*, 34.
Stellar Motions, Some Problems of, *R. M. Petrie*, 1.

Stewart, R. Meldrum, Gravity in the Interior of the Earth, 129.

T

Telescope, Victoria Centre's "Brydon", 248.
Telescopes, Star Diagonals on Finder, *F. K. Dalton*, 34.
Time, The Galaxies and, *Otto Blüh*, 169.
Time Service Notes: Earthquake Observation by Transit Telescope, 211.
Two RV Tauri-type Variables in Globular Clusters, *Helen B. Sawyer*, 38.

U

Universe — Whence? The, *J. W. Campbell*, 49.

V

van Dien, Elsa, The Spectrum of Epsilon Aurigae, 1946-1948 (with K. O. Wright), 15.
Variables in Globular Clusters, Two RV Tauri-type, *Helen B. Sawyer*, 38.
Victoria Centre's "Brydon" Telescope, 248.

W

Welsh, H. L., The Extent of the Chromosphere of the K-type Component of Zeta Aurigae, 217.
Wright, K. O. The Spectrum of Epsilon Aurigae, 1946-1948 (with Elsa van Dien), 15.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, F. S. HOGG

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

J. A. PEARCE
Dominion Astrophysicist
Victoria, B.C.

A. THOMSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED BI-MONTHLY
(*Six numbers per year*)

VOLUME XLIII, 1949

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

THE UNIVERSITY OF TORONTO PRESS

CONTENTS FOR VOLUME XLIII, 1949

I. JANUARY-FEBRUARY

		PAGE
Some Problems of Stellar Motions	*R. M. Petrie*	1
The Spectrum of Epsilon Aurigae, 1946-1948 (with Plate I)	*K. O. Wright* and *Elsa van Dien*	15
Star Diagonals on Finder Telescopes	*F. K. Dalton*	34
Two RV Tauri-type Variables in Globular Clusters (with Plate II)	*Helen B. Sawyer*	38
Out of Old Books (The Early Discovery of Four Globular Clusters)	*Helen Sawyer Hogg*	45

II. MARCH-APRIL

The Universe—Whence?	*J. W. Campbell*	49
International Astronomical Union, 1948	*A. Vibert Douglas*	61
Annual General Meeting of the Royal Astronomical Society of Canada: Chant Medal Presentation, Reports of the Recorder, General Secretary, Librarian, Secretaries of the Centres, General Treasurer and Treasurers of the Centres; Officers for 1949		66
Review of Publications (*Centennial Symposia,* Harvard Observatory Monographs, No. 7: *F.S.H.*)		93
Meetings of the Society—Toronto, Saskatoon, Edmonton		94

III. MAY-JUNE

The Lure of Underground Treasures	*Lachlan Gilchrist*	97
Simultaneous Observations of Solar Radio Noise on 1.5 Meters and 10.7 Centimeters	*A. E. Covington* and *W. J. Medd*	106
Review of Publications (*Skalnate Pleso Atlas of the Heavens* by A. Becvar: *J.F.H.; Gnomonicky Atlas Hvezdne Oblohy* by V. Guth: *J.F.H.; Human Knowledge: its Scope and Limits* by Bertrand Russell: *R. L. Baglow*)		111
Out of Old Books (Jean Sylvain Bailly, The Guillotined Astronomer)	*Helen Sawyer Hogg*	117
Notes and Queries (Detonating Fireball in the Bruce Peninsula: *J. F. Heard;* Sky Survey (with Plates III and IV); Perfecting the 200-inch Mirror: *C.A.C.;* L'Astronomie: *Joseph Edgar Guimont*)		122
Meetings of the Society—Montreal, Toronto		125

IV. JULY-AUGUST

Gravity in the Interior of the Earth	*R. Meldrum Stewart*	129
American Astronomical Society: Eighty-first Meeting	*C. A. Chant*	138
Radial-velocity Curves for Delta Cephei from Lines of Different Chromospheric Levels	*T. S. Jacobsen*	142

The Fireball of April 3, 1949 ..... *John F. Heard* 149
Notes and Queries (Amateur Observatories in Canada: *C.A.C.*; Nova in Scutum: *J.F.H.*) 161
Meetings of the Society—Edmonton, Ottawa, Toronto 162

V. SEPTEMBER-OCTOBER

The Galaxies and Time ..... *Otto Blüh* 169
The Perpetual World Calendar that we Need ..... *Conrad M. Morin* 181
Out of Old Books (Jean Sylvain Bailly, The Guillotined Astronomer cont'd.) ..... *Helen Sawyer Hogg* 195
Review of Publications (*Skyshooting, (hunting the stars with your camera)* by R. Newton Mayall and Margaret L. Mayall; *Our Sun* by Donald H. Menzel: *F.S.H.*; *Atomic Energy Levels*, Volume I, by Charlotte E. Moore: *J.F.H.*; *Our Wonderful Universe* by C. A. Chant: *F.S.H.*) 204
Notes and Queries (The Astronomer Royal Visits the United States; The Loon's Necklace: *C.A.C.*; Time Service Notes:– Earthquake Observation by Transit Telescope) 208
Meetings of the Society—Winnipeg, Toronto 212

VI. NOVEMBER-DECEMBER

The Extent of the Chromosphere of the K-type Component of Zeta Aurigae ..... *H. L. Welsh* 217
Observations of the Total Solar Eclipse at Araxa, Brazil, 1947, May 20 ..... *James Hargreaves* 229
Out of Old Books (Jean Sylvain Bailly, The Guillotined Astronomer, concluded) ..... *Helen Sawyer Hogg* 237
Review of Publications (*The Conquest of Space* by Chesley Bonestell and Willy Ley: *J.F.H.*; *Scientific Autobiography and other papers* by Max Planck; *Tycho Brahe's Description of his Instruments and Scientific Work* as given in Astronomiae Instauratae Mechanica translated and edited by Hans Raeder, Elis Strömgren and Bengt Strömgren: *C.A.C.* 241
Notes and Queries (Bright October Meteors over Ontario: *J.F.H.*; Victoria Centre's "Brydon" Telescope; Four Eclipses in One Evening: *F. K. Dalton.*) 247
Meetings of the Society—Toronto, Quebec 251
Index to Volume XLIII 254
Table of Contents of Volume XLIII ..... i-iv

The Royal Astronomical Society of Canada

OFFICERS FOR 1949

Honorary President—THE HONOURABLE DANA A. PORTER, Minister of Education for the Province of Ontario
President—ANDREW THOMSON, M.A., Toronto
First Vice-President—C. S. BEALS, PH.D., Ottawa
Second Vice-President—J. F. HEARD, PH.D., Toronto
General Secretary—E. J. A. KENNEDY, 3 Willcocks St., Toronto
General Treasurer—J. H. HORNING, M.A., Toronto
Recorder—H. W. BARKER, Toronto
Librarian—D. W. BEST, D.D., Toronto
General Council—CHARLES A. BELL, B.A., Windsor; ALBERIC BOIVIN, B.SC., Quebec, P.Q.; A. J. COOK, Edmonton, Alta.; F. DEKINDER, Montreal P.Q.; M. J. S. INNES, M.A., Ottawa; GORDON R. MAGEE, PH.D., London; L. T. S. NORRIS-ELYE, Winnipeg, Man.; RUTH J. NORTHCOTT, M.A., Toronto; GORDON SHAW, Victoria, B.C.; G. M. SHRUM, PH.D., Vancouver, B.C.; W. D. STEWART B.A., Hamilton; F. L. TROYER, Toronto, and Past-Presidents—J. W. CAMPBELL, PH.D., and A. E. JOHNS, PH.D.; also the presiding officer of each centre.

TORONTO CENTRE

Honorary President—C. A. CHANT, PH.D.
President—A. R. CLUTE, K.C.
First Vice-President—FRANK S. HOGG, PH.D.
Second Vice-President and *Secretary*—FREDERIC L. TROYER, 43 Adelaide St. E., Toronto 1.
Treasurer—T. H. MASON
Recorder—F. KEITH DALTON, B.SC.
Council—D. S. AINSLIE, PH.D.; GEORGE T. DALE; FRED. T. GRAHAM; GORDON HEPBURN, B.A.SC.; MISS A. HISCOCK; RAYMOND PEARCE; T. N. SMITH; R. E. WILLIAMSON, PH.D.; and NORMAN N. WRONG, M.D., and the Past Presidents—E. J. A. KENNEDY; J. R. COLLINS; S. C. BROWN; REV. D. W. BEST; MISS RUTH J. NORTHCOTT, M.A.; H. W. BARKER and J. F. HEARD, PH.D.

OTTAWA CENTRE

Honorary President—R. M. STEWART, M.A.
President—P. M. MILLMAN, PH.D.
First Vice-President—DR. D. A. MACLULICH *Second Vice-President*—M. J. S. INNES, M.A.
Secretary—MISS C. B. HICKS, B.A., B.L.S., 43 Florence St., Apt. 2, Ottawa, Ontario.
Treasurer—S. A. MOTT
Council—C. S. BEALS, PH.D.; F. W. MATLEY; MIRIAM S. BURLAND, B.A.; GEORGE OLTMANN; R. G. MADILL; and Past Presidents—T. L. TANTON, PH.D.; HOYES LLOYD, M.A.; M. M. THOMSON, B.A.

HAMILTON CENTRE

Honorary President—W. T. GODDARD
President—T. M. NORTON
Vice-President—W. J. MCCALLION, M.A.
Secretary-Treasurer—GEORGE MURCHIE, 77 Fennel Ave. W., Hamilton, Ont.
Curator—G. E. CAMPBELL, M.A.
Council—REV. E. F. MAUNSELL, M.A.; F. SCHNEIDER; F. SISMAN; W. D. STEWART, B.A.; L. O. JONES; O. J. PATON; J. E. CRAIGMYLE; B. WISHART.

WINNIPEG CENTRE

Honorary President—DR. L. A. H. WARREN
President—H. E. RASMUSSEN
Vice-President—C. G. CARD
Treasurer—MISS M. WATTERSON
Secretary and *Recorder*—MISS P. FOX, 607 South Drive, Fort Garry, Manitoba.
Council—C. L. CARD; L. T. S. NORRIS-ELYE; H. C. FAIRFIELD; A. V. THOMAS; V. C. JONES; D. P. R. COATS.

VICTORIA CENTRE

Honorary President—DR. R. M. PETRIE
President—DR. J. S. STEVENSON
First Vice-President—MRS. J. R. NOBLE
Second Vice-President—R. S. EVANS
Secretary-Treasurer—MRS. J. H. WILLIAMS, Dominion Astrophysical Observatory, Victoria, British Columbia
Recorder—R. C. FAIRALL
Director of Telescopes—R. PETERS
Librarian—E. H. POPE
Council—MRS. E. CHESMAN; G. L. DARIMONT; JOHN JERVIS; REV. T. TAYLOR; M. C. TRUEMAN; F. R. WILLIAMS; MRS. C. S. YARWOOD

MONTREAL CENTRE

Honorary President—G. H. HALL
Honorary Vice-President—DR. A. N. SHAW
President—J. W. DUFFIE
Vice-President—F. DEKINDER
Secretary—H. F. HALL, 1441 Drummond St., Montreal, P.Q.
Recording Secretary—MISS I. K. WILLIAMSON
Treasurer—C. N. S. YARNELL
Director of Observations—DELISLE GARNEAU
Librarian—C. M. GOOD
Past President—D. P. GILMOR, K.C.
Council—DR. W. B. ROSS; DR. D. E. DOUGLAS; E. E. BRIDGEN; A. M. DONNELLY; ROSS FORD; ARTHUR KNEELAND; A. R. MACLENNAN; F. P. MORGAN; W. H. C. MORTON; E. R. PATERSON.

LONDON CENTRE

Honorary President—DR. H. R. KINGSTON
President—ALBERT EMSLEY
Vice-President—REV. W. G. COLGROVE
Secretary-Treasurer—MRS. A. DAVIES, 197 Central Ave., London, Ont.
Past President—DR. A. J. WATT
Council—O. KILBURN; MRS. J. C. HIGGINS; M. O. CULBERT; J. W. BRYCE; E. E. O'CONNOR

(Continued at bottom of next page)